Center Innovation Fund: GRC CIF

Sensitive, selective nanoantenna-based biosensor platform for compact, in-situ exo-life detection and astronaut life support

Completed Technology Project (2017 - 2018)

Project Introduction

We aim to develop a new nanotechnology-enabled sensing platform exceeding the sensitivity and selectivity of the current state-of-art (SOA) in portable, low-mass, low-complexity biochemical sensors. This system is a new capability for space exploration/science applications, e.g. exo-life detection in challenging cryogenic environments, including multiplexed arrays in planetary probes, distributed sensor swarms for use with CubeSats, and other platforms, and builds upon our existing efforts at both NASA Glenn Research Center (GRC) and Dartmouth College. Localized surface plasmon resonances (LSPRs) - the collective electron oscillations excited in nano-sized metallic particles ('nanoantennas') by incident optical light - have been utilized extensively as sensitive, label-free optical probes for the study of biochemical interactions in both gas and liquid phase, due to their highly confined electric fields and extreme sensitivity to changes in their local environment (e.g. the presence of a target biomolecule.) The ultimate limit of detection - single molecule detection - has been demonstrated with such sensing platforms, and will form the basis of our sensing approach. Yet, the selective capture of rare targets from a complex background near these transducers remains both a challenging problem and necessary step to advance this technology out of the lab and into the field. Therefore, we aim to close this critical knowledge gap in the current proposal, through the development of the tailored nano-recognition elements coupled to sensitive plasmonic nanoantennas. We will primarily focus on exo-life applications - as these are currently the most challenging and least understood - but with further application to astronaut life support, pathogen detection, and water quality monitoring. Field-deployable LSPR-based sensors are currently being explored for terrestrial point-of-care (POC) medical applications by other groups, including our external collaborator for this award at Dartmouth College. These devices are also conducive to the demanding requirements of space exploration, owing to their low-mass, volume, and power consumption, and ruggedization/simplicity in operation. Further, their small size, and relatively low cost with high sensitivity provide capabilities not possible with larger, more complex, centralized instruments (e.g. mass spectrometer). However, LSPR-based sensors (and mass spectrometers) are limited in their demonstrated ability to selectively capture and uniquely identify the target analytes in-situ (in possibly challenging environments), with minimal processing/contamination. This proposal is aimed at enabling this critical step towards a new class of chemical/biochemical measurements for space exploration applications. The goal is to advance the SOA in selective capture and sensitive detection of rare biomarkers in-situ, using small, portable, deployable biosensor platforms, with a particular focus on exo-life detection, and possible extension/application to in-flight astronaut life support (including water quality monitoring, health diagnostics, and pathogen detection).

Anticipated Benefits

Sensitive, selective nanoantenna-based biosensor platform for compact, in-situ exo-life detection and astronaut life support

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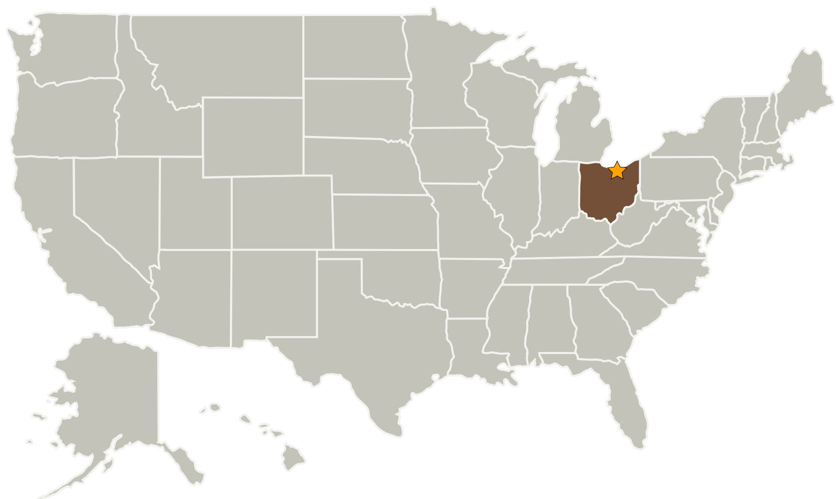
This newly demonstrated technology could have significant impact on in situ life detection/astrobiology for both in-development and future NASA missions. Lab-on-chip life detection instruments, especially for application to cryogenic environments, do not currently exist and would have an impact core to the viability of future missions to the ocean worlds/icy moons of the outer Solar System. The results of this project represent a critical step towards realizing this capability. Further impact of this project may be seen in astronaut life support, where similar compact, selective/sensitive devices can target key biomarkers for crew health (e.g. air/water quality). Finally, there is significant potential for commercial applications, especially in point-of-care medicine, terrestrial life detection (e.g., in extreme environments), and field-deployable biochemical sensors for pathogen/threat detection in homeland security/military applications - all of which will benefit from more selective, more sensitive, miniaturized sensing platforms, such as those developed in this project.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio
Dartmouth College	Supporting Organization	Academia	Hanover, New Hampshire

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Glenn Research Center (GRC)

Responsible Program:

Center Innovation Fund: GRC CIF

Project Management

Program Director:

Michael R Lapointe

Program Managers:

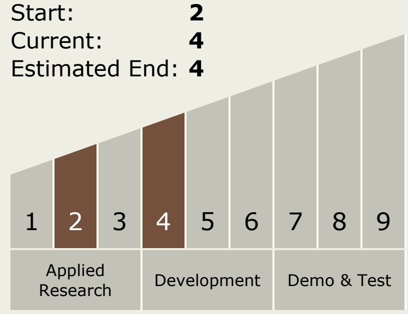
Kurt R Sacksteder
Gary A Horsham

Principal Investigator:

Timothy J Palinski

Technology Maturity (TRL)

Start: **2**
Current: **4**
Estimated End: **4**



Primary U.S. Work Locations

Ohio

Project Transitions

October 2017: Project Start

September 2018: Closed out

Closeout Summary: This project determined a suitable sensor design (waveguide-coupled plasmonic nanogratings) to pursue for in situ, lab-on-chip astrobiology applications. This sensor is capable of low-temperature operation (tested to 80 K, relevant to icy moons surface conditions), has demonstrated sensitive/specific detection of the relevant target biomarkers, and is compatible with miniaturization/lab-on-chip integration. The preliminary results in this project show that this is a viable path forward for further development/infusion. The current maturity is TRL 4. Several paths were identified to continue this work, including STMD, SMD and HEOMD.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX04 Robotic Systems
  - └─ TX04.3 Manipulation
    - └─ TX04.3.4 Sample Acquisition and Handling

Target Destinations

Earth, Mars, Others Inside the Solar System